Soybeans for the Tropics from AVRDC*

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Soybean, *Glycine max* (L.) Merrill, is a temperate crop. The demand for protein has increased worldwide in recent years. Since soybean is a high protein crop there is a growing interest in expanding the area and production of soybean. Until recently most of the soybean varietal development and crop improvement work was concentrated in temperate countries. As a result the concepts of soybean development tend to be biased towards the problems of temperate countries. Recognizing the high protein content of soybean and its direct and indirect role in human nutrition, efforts were undertaken to increase its production in tropical countries. One such effort was to include soybean as one of the major crops for improvement in the tropics at the Asian Vegetable Research and Development Center (AVRDC). Improved soybean cultivars and research developed in the temperate areas are recognized where these are relevant to the tropics. But differences between temperate and tropical environments and cropping systems mean a different approach to developing soybeans for the tropics.

AVRDC's Goals in Developing Tropical Soybeans

AVRDC is located almost on the Tropic of Cancer. Our goal is to develop breeding lines which can perform well not only at AVRDC but also at various locations between the Tropic of Cancer and the Tropic of Capricorn. In the tropics the potential exists to grow soybeans the year round, unlike the temperate areas. Environmental conditions vary depending on location and season. Diseases and insect pests which inflict damage and limit soybean production in the tropics are quite different from those in temperate areas. Scientific information on various aspects of soybean management is grossly inadequate in the tropics. The type of cropped system in which soybeans are included dictates the type of soybean cultivar needed for production. Based on the above considerations the following goals were defined, on a problem-oriented basis, in developing tropical soybeans :

1. Assemble, screen, maintain and distribute germplasm

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1,2 : Associate Plant Breeder and Research Assistant respectively.

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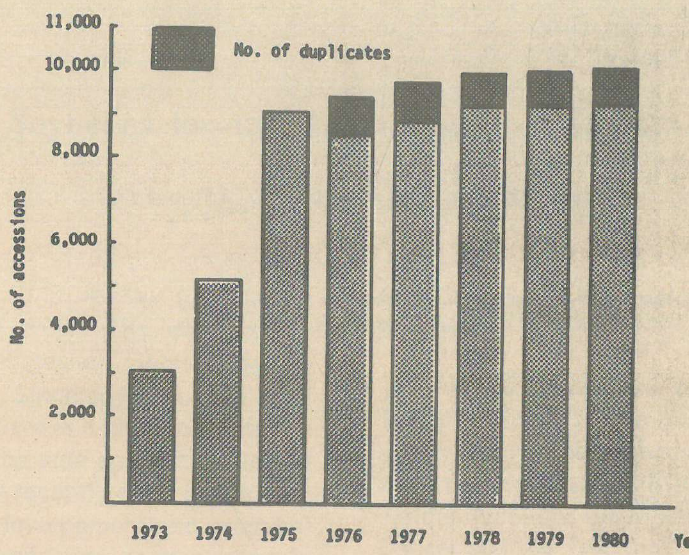


Fig. 1. Growth of soybean germplasm bank from 1973 to 1980 at AVRDC.

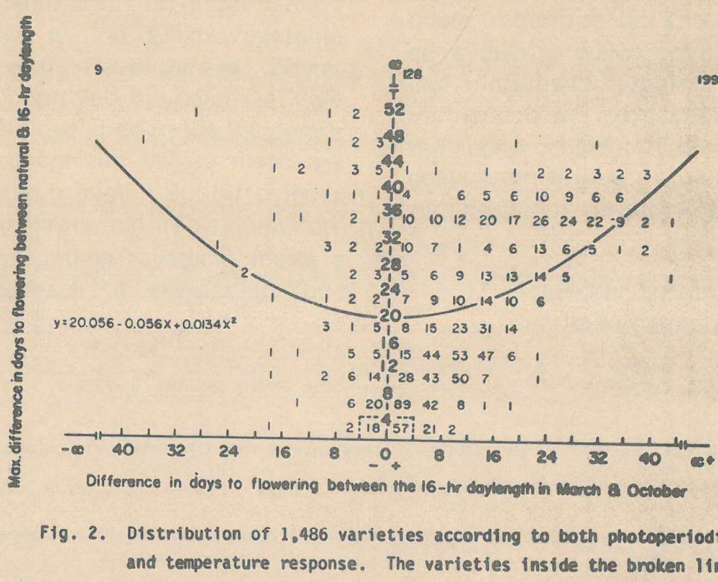
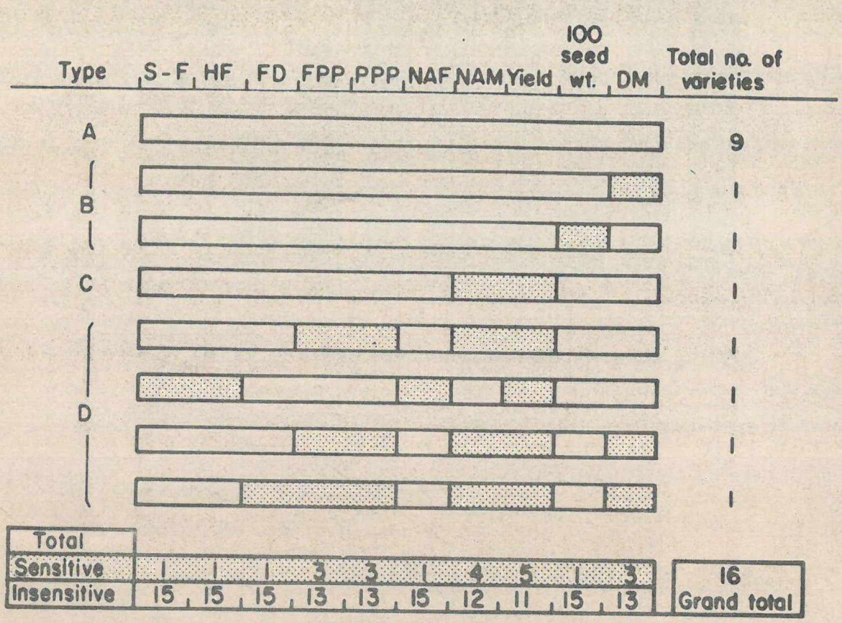


Fig. 2. Distribution of 1,486 varieties according to both photoperiodic and temperature response. The varieties inside the broken line zone are less sensitive to both photoperiod and temperature.



S-F = Sowing to flowering
HF = Height at flowering
FD = Flowering duration
FPP = Flowers per plant
PPP = Pods per plant
NAF = No. of nodes at flowering
NAM = No. of nodes at maturity
Yield = Grain yield per plant
DM = Days to maturity

Fig. 3. Classification of 16 varieties into 4 different types.

2. Develop early-maturing, high-yielding selections with good seed quality
3. Incorporate photoperiod and temperature insensitivity for wide adaptability
4. Identify resistance to major diseases and insect pests and develop genetically resistant selections
5. Select appropriate plant types for intercropping systems
6. Evolve suitable vegetable types for direct consumption

Germplasm Collection

The AVRDC soybean germplasm collection commenced in 1973. In less than a decade the AVRDC soybean germplasm bank has accumulated a huge gene-pool, a soybean "treasure of mankind" upon which the world's scientists, especially those in the tropics, can draw to develop new soybean cultivars (Fig. 1).

Screening for Photoperiod end Temperature Response

Soybean germplasm have been evaluated in temperate countries, and in U. S. A. and Japan, and classified into different maturity groups based on their latitude of adoption. When U. S. and Japanese classification is used, the different planting times throughout the year in the tropics cause complications. The behavior of cultivars within groups varies from season to season, and even within a single season identity of the the group can be lost. Therefore the U. S. and Japanese maturity classification system of soybean is not applicable to the tropics. A new soybean classification system has been proposed based on photoperiodic response and days to maturity when planted at different photoperiods.

A representative sample of germplasm consisting of 1,486 cultivars was screened for photoperiodic response during March and October at AVRDC. Among these, 75 were insensitive to photoperiod and temperature. The photoperiodic and temperature response gave a best fit for the curvilinear regression equation $y = 20.056 - 0.056X + 0.0134X^2$ (Fig. 2). Nine such cultivars out of 16 screened were found to be insensitive to 10 different traits (Fig 3). The yield stability of the four different types shown in fig. 3 needs to be examined across a range of environments.

Screening for Resistance to Diseases

In the tropics the most important soybean diseases are : bacterial pustule, *Xanthomonas phaseoli* (Smith) Dawson var. *sojensis* (Hedges) Starr and Burk ; wildfire, *Pseudomonas tabaci* (Wolf and Foster) F. L. Stevens ; bacterial blight, *Pseudomonas glycines* Coerper ; soybean rust. *Phakopsora pachyrizi* Syd ; frog eye leaf spot, *Cercospora sojina* Hara ; target spot, *Corynespora cassiicola* (Berk and Curt) Wei ; anthracnose. *Colletotrichum dematicum* (pers. ex Fr.) Grove var. *truncata* (Schw.) Arx ; soybean mosaic virus (SMV) and soybean yellow mosaic virus.

Since genetic resistance has been observed and reported for many of the above diseases in the temperate countries, AVRDC's efforts are concentrated in screening for diseases which are either not present in the temperate areas

TABLE 1. Soybean varieties identified as moderately resistant to soybean rust, and their characteristics

Acc. No.	Name or P.I. number	Country of Origin	Percent affected foliage date			Days to Maturity	Yield t/ha	100 Seed wt. (gm)
			18 May	25 May	1 June			
G 2041 [b/]	Taira Kaohsiung 5	Taiwan	60	98	M[a/]	98	1.7	15
G 4919	Akiyoshi	Japan	2	10	M	98	1.4	26
G 5095	Yoshida-2	Japan	N	1	M	98	1.2	44
G 5422	Sanga	Manchuria	N	5	M	106	2.3	26
G 5524	70559	Manchuria	N	2	M	98	1.4	23
G 5525	70561	Manchuria	N	3	M	94	1.4	19
G 5554	79610	Manchuria	N	2	M	98	1.4	23
G 6154	68728	Manchuria	N	2	M	98	0.4	19
G 8566	230970	Japan	N	N	25	129	2.0	17
G 8587	230971	Japan	N	N	25	129	2.3	21

a/ M=Matured. Sown on Feb. 20, 1979

b/ : Susceptible check

N : Negligible (values of 0.1 to 0.001)

or for which no reliable resistant source is presently available. Soybean rust is one such disease. After screening the whole germplasm collection, nine accessions were found to be moderately resistant to soybean rust (Table 1). In Thailand the newly released S. J. 5 appears to be somewhat resistant to anthracnose. At AVRDC, 27 accessions were identified to be immune to a strain of SMV (Table 2) and 16 accessions previously reported as resistant to SMV proved to be symptomless but susceptible to SMV (Table 3).

Screening for Resistance to Insect Pests

Among insect pests, the following can cause severe demage and result in yield reduction : beanfly, *Melanagromyza sojae* and *Ophiomya centrocematis* ; green stink bug, *Nezara viridula* L. ; pod borer, *Etiella zinkenella* ; Mexican bean beetle, *Epilachna varivestis* Mulsant ; soybean looper, *Pseudoplusia includens* Walker ; and the potato leaf hopper, *Empoasca fabae (Harris)*.

We have screened our germplasm for beanflies and pod borers and identifi- a few resistant accessions (Table 4 and 5).

Yield Potential of Soybean in the Tropics

Indonesia, Thailand, Neplal, parts of India, Srilanka, Bangladash, Taiwan and the Philippines represent tropical environment suitable for soybean in Asia. The average yield of soybean in these countries is below 1 t / ha except in Taiwan where the average yield is about 1.8 t / ha. Indonesia, Thailand, India and Taiwan have large acreage under soybean.

TABLE 2. Soybean varieties immune to soybean mosaic virus.

AVRDC Acc. No.	Name or P. I. number	Origin
G 270	PI 153262	Belgium
C 288	PI 180501	Germany
G 358	PI 248403-1	Unknown
G 452 (G 453)	PI 84668	Korea
G 801	PI 84920 909	Unknown
G 1200	PI 89109	Japan
G 1242	92590	Unknown
G 1501	PI 157409	Korea
G 1563	246367	Unknown
G 1601	PI 62204-1	China
G 1711	85476	Korea
G 1742	96257-T	Korea
G 1814	84642	Korea
G 1902	224269	Japan
G 2167	Kyungdu	Korea
G 2178	Olkibal	Korea
G 2201	Pochal	Korea
G 2242	108-1	Korea
G 2247	208	Korea
G 2431	Hahto 65096	Nigeria
G 2447	Hardee x 127-689	Nigeria
G 2530	206-M-4-M-1-M (6)	S. America
G 2545	L 215-M(4)-6-M) (6)	Sr America
G 2666	Yogetsu	Japan
G 2699	Kinoshita (8)	Japan
G 2700	Aogaridaizu-Karikel-1	Japan
G 2769	Date Koshichi	Japan

TABLE 3. Soybean varieties which are susceptible to soybean mosaic virus but without symptoms (W. Lim, personal communication)

AVRDC Acc. No.	Name or P.I. Number	AVRDC Acc, No.	Name or P.I. Number
G 171	PI 159764	G 2042	Tainung 3
G 260	PI 153241	G 2166	Kwangkyo
G 311	PI 189898	G 2415	Willel 1
G 328	PI 227327	G 2416	X 8/3
G 394	Orsoy	G 2546	215-m(4)-9-m(6)
G 519	PI 153263	G 2620	Daiga-daizu
G 1096	80461 201	G 2656	Chotan
G 1146	PI 85666	G 2835	PI 89769-1

TABLE 4. Wild soybean, (*G. Soja* Sieb and Zucc.) accessions least affected by beanflies (*Melanagromyza sojae and Ophiomyia centrocematis*) at AVRDC.

AVRDC Acc. No.	Korean No.	Location collected*
G 3089	K 7	Maseogu, Yanguju, Gyeonggi-do, Korea
G 3091	K 10	Dongsan, Chunseong, Gangweon-do Korea
G 3104	K 24-A	Manchong, Jungweon, Chung-buk-do, Korea
G 3122	K 40	Bang, Changnyong. Gyeongnam-do, Korea

Total germplasm screened 6,775.

a/ Village, sub-county, county, province and country respectively (E.H. Hong, personal communication).

Source: AVRDC 1979. Progress report for 1978. Shanhua, Tainan 741, Taiwan.

TABLE 5. Soybean varieties less affected by pod borer, *Etiella zinkenella* at AVRDC

AVRDC Acc. No.	Name or No.	Origin
G 2102	Bilomil	Indonesia
G 2105	949 Ex Israella	Indonesia
G 3473	Hitam Pasir	Indonesia
G 3517	975	Indonesia
G 3818	Black Matted Java LTS 92	Australia

Total germplasm Screered 3,298

Source: AVDRC 1979. Progress report for 1978, Shanhua, Tainan 741, Taiwan.

TABLE 6. Cultivars with high yield potential in the tropics

Cultivar	Country	Latitude	Elevation (m)	Yield t/ha	Days to maturity
Bossier	Sri Lanka	9°2′ N	9	5.2	94
	Venezuela	10°14′ N	450	5.4	109
Bragg	Sri Lanka	9°6′ N	1	5.7	105
Calland	Ecuador	2°21′ S	17	4.1	98
		1°4′ S	44	4.4	98
Clark 63	Sri Lanka	9°6′ N	1	5.7	91
Davis	Sri Lanka	9°2′ N	9	5.4	99
Forrest	Sri Lanka	9°6′ N	1	5.3	97
Hardee	Sri Lanka	9°6′ N	1	6.0	113

Source: Whigham, 1975, INTSOY series No. 8, Univ. of Illinois, Ill., U.S.A.

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AVRDC SELECTION NO.	YIELD (T/HA) SOWING TIME		
	FEBRUARY	JULY	SEPTEMBER
AGS 19	2.6	2.8	2.2
AGS 66	3.4	3.1	
AGS 129	4.0	3.4	2.6
AGS 130	3.8	3.0	2.5
AGS 131	3.8	2.8	
AGS 133	3.5	3.3	
AGS 135	3.8	3.0	2.5
AGS 144	4.3	3.0	2.2

Fig. 4. AVRDC selections with high yield potential and adapted to different seasons.

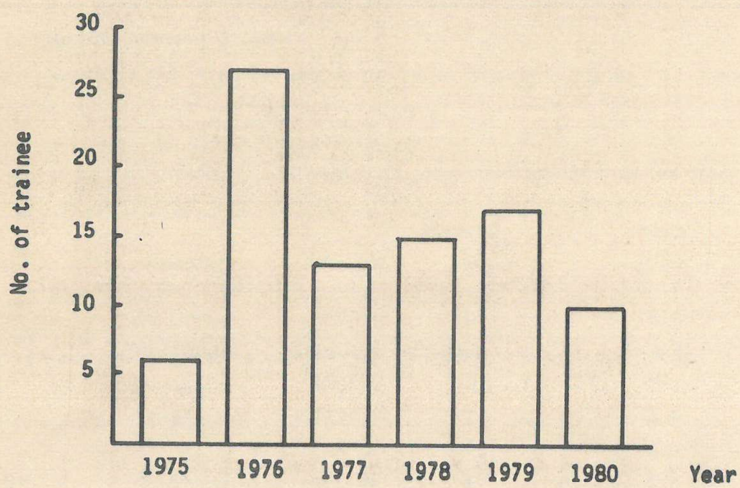

Fig. 5. Number of trainees in the Legume Program at AVRDC during 1975-1980.

TABLE 7. AVRDC selections which have yield potentials of 4 t/ha or more in about 100 days

AVRDC No.	Cross No. of pedigree	Yield t/ha	Days to maturity	Yield/ha/day (kg)
AGS 59	GC 30187-10-9	4.2	103	41
AGL 108	GC 40359-1-104-8	4.1	102	40
AGS 127	GC 50232-2-19	4.4	108	41
AGS 129	GC 30229-8-7	4.1	107	38
AGS 130	GC 30104-2-56	4.4	107	41
AGS 131	GC 30251-10-43	4.0	107	37
AGS 144	Selection from T 17	4.3	103	42

International Soybean Variety Experimental (ISVEX) trails in a number of tropical locations have shown that a yield potential of up to 6 t/ha is possible in the tropics (Table 6). AVRDC yield trials have shown that our G 2120 has a potential yield of 7 t/ha. In many of the AVRDC yield trails several of our selections gave yield of 4 t/ha or more in about 100 days (Table 7). The yield/ha/day reached as high has 36 kg. With varietal development alone it should be easily possible to double the present-day yields in countries like Indonesia and Thailand.

Hybridization And Selection

The impressive genetic diversity available in the soybean germplasm bank has been judiciously used in making suitable cross combinations. Efforts are being made to combine early maturity, photoperiod and temperature insensitivity, high yield resistance to diseases and insects and good seed quality into a single variety. In temperate countries it has often been remarked that all of the present-day cultivars can be traced back to a few selected accessions. The genetic base of these cultivars is rather narrow. Especially in the U. S., since the soybean germplasm there has been classified into different maturity groups with each group having adaptability to a narrow range of latitude, soybean breeders tend to limit crosses within the maturity groups. As a result, gene flow and recombinations between maturity groups are restricted. In the tropics, however, all the wealth of germplasm can flower and mature. AVRDC has utilized this oportunity to intercross diverse genetic meterials for selection of early maturity and wide adoptability. It is true that the majority of the early maturing germplasm in the tropics are poor yielders. However by crossing late maturing tropical types and early maturing temperate types, a new series of early maturing, high yielding, widely adopted selections is being generated at AVRDC. Since 1973, 2,794 crosses have been made to combine desirable characteristics. Untill the F_5 generation the population are advanced as bulks. Thereafter selections are made and disruptive seasonal selection is used to select the widely adopted types. A few of the promising selections adopted to different seasons are shown in Fig. 4. Although our selections are relatively less sensitive to photoperiod and temperature regimes represented at AVRDC during three seasons, our data show that the population is still heterogeneous for that environmental response. A homogeneous population is being developted to be compared with the heterogeneous population in diverse environments (with wide latitude differences in the tropics) to determine advantages and disadvantages of the two in terms of wide adoptability.

New Programmes

Genotypes selected under monocropping conditions were found to be unsuitable for intercropping. Similarly grain types differ distinctly from the vegetable types. Therefore, a new programme has been initiated to select genotypes suitable for intercropping system. Initially corn is being used to screen the genotypes. A seperate project has been started to select suitable vegetable types for different locations.

Worldwide Cooperation

One of AVRDC's mandates is to assist national programs to help themselves. We cannot emphasize enough that neither AVRDC nor any other international agricultural research center can replace the national programs, but canonly complement them. AVRDC offers its expertise and seed materials as backup to the research efforrs of national programs in many countries. Since 1973 a total of 32,243 seed packets of germplasm, segregating materials and selected pedigree lines have been distributed to co-operators in 68 countries. In south India at Tamilnadu, the Department of Agriculture has released AVRDC G 2120 as cultivar Kudimiamalai-1 (KM-1) for planting in rice fallows. The same selection G 2120 is being extended to farmers in East Java by the ROC's Overseas Technical Mission Team because it is high yielding, adapted to crude cultivation and has good seed quality compared to local cultivars. In Honduras AVRDC'S AGS 29 has been released as Darco-1 by the International Volunteer Service agronomist in cooperation with the soybean program.

The national programs in Thailand Taiwan, Phillippines, Pakistan, India, Nepal are also using AVRDC'S germplasm and the breeding lines as source materials in developing new soybean cultivars. AVRDC has become instrumental in stimulating the national programs to make rapid and practical progress in improving soybean production.

With the introduction of a standard AVRDC Soybean Evaluation Trial (ASET) there are plans to test the newly-developed photoperiod insensitive selections to identify high-yielding, widely-adapted types which have the potential to become cultivars in widely differing environments.

Transferring Improved Technology

With improved cultivars and new technology it is necessary to have a sufficient number of suitably trained personnel to increase production. AVRDC has excellent staff and facilities to offer training for dedicated, research and extension specialists from the developing countries. The training includes both theoretical and practical skills in growing soybeans in the tropics. To date, AVRDC has trained 84 specialists from 8 countries in soybean production (Fig. 5).

Concluding Remarks

The true potential of soybeans in the tropics is yet to be exploited. The development of new, early-maturing, high-yielding, disease-resistant, widely-adapted soybean selections from AVRDC and the accomplishments of properly trained national program scientists should bring about a 'protein revolution' in the tropics. To achieve this, concerted efforts should be made by countries in the tropics to cooperate intensively with AVRDC and utilize to the full both the germplasm bank and the breeder's stock to develop and release new cultivars which will revolutionize soybean production in the tropics.